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Real-Time Prospective Seizure Prediction and Statistical Assessment

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Purpose: Improving seizure prediction is one of the most important future directions for epilepsy research (Jacobs, 2001). The ability to predict epileptic seizures well before clinical onset promises new diagnostic applications and novel approaches to seizure control. Our group initially reported the predictability of seizures based on the quantitative analysis of EEG signal characteristics (Iasemidis and Sackellares, 1996; Iasemidis et al., 1998; Sackellares et al., 1999). This finding has been confirmed by other investigators (Lehnertz and Elger, 1998; Quyen et al., 1999; Litt et al., 2001; Iasemidis et al, 2001, 2002). We have previously described an automated seizure prediction algorithm (Iasemidis et al., 2003). The objective of this study was to statistically evaluate the performance of an improved automated algorithm for seizure prediction.

Methods: Continuous long-term (total 71.4 days) intracranial EEG recordings obtained from eight patients with intractable epilepsy (total 123 recorded seizures with mean seizure interval 10.6 hours) were analyzed to test the proposed algorithm. The algorithm utilizes concepts from nonlinear dynamics, statistics, an optimization method for the selection of critical cortical sites, and a novel method for the detection of the preictal transitions using adaptive thresholds according to the state of the EEG dynamics. Prediction receiver operating characteristic (ROC) curves from each patient were compared to ones produced by a statistically derived optimal naïve prediction method and two other naïve prediction methods (periodic and random). Standard meta-analysis was employed to obtain the overall significance (p-values) of the proposed prediction algorithm with respect to the optimal, periodic and random prediction algorithms.

Results: The meta-analysis showed that the performance of the proposed seizure prediction algorithm is significantly superior to the optimal naïve prediction method (p-value < 0.01) and the other two naïve methods, whereas the comparison of the two naïve prediction methods with the optimal naïve method showed that their prediction performances are not significantly different (p-values are 0.976 and 0.811 respectively).

Conclusions: The prediction performance of the proposed automated seizure prediction algorithm is superior to three compared naïve prediction methods (optimal, periodic and random). Further, the overall prediction sensitivity is 83.5% with false prediction rate 0.14/h and average prediction time 54 minutes prior to seizure onsets. This study again confirms the hypothesis that it is possible to prospectively predict an impending seizure a long time before its occurrence.

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